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ABSTRACT

This document describes some of the many programs sponsored by the National Science Foundation in its efforts to continue to promote systemic science and mathematics education reform. Brief descriptions of the following programs are included: (1) Interactive Math Program Restructures 9-12 Math Education; (2) Algebra I Project Sparks Citywide Mathematics Curriculum Reform; (3) A River Runs Through It: Interdisciplinary Curriculum in 250 Schools; (4) Calculus Leading the Way; (5) Air, Earth, Fire, Water--What Do These Have to Do with Modern Chemistry?; (6) Educating the Technical Work Force for the 21st Century; (7) Promoting Technology Transfer; (8) Hampton University Spearheads Increased Production of Doctorates in S&E by HCBUs; (9) Isolated Colleges Ride the Information Highway; (10) CGI: "You Sort of Take What They Know and Build from There"; (11) Science Comes to Television: "Bill Nye the Science Guy" and "CRO" with School Kits Too; (12) 180 Students Demonstrate the Art and Science of Engineering--Some Even Invented Equipment for the Disabled; (13) Students in the Global Laboratory Make Their School a Safer Place; (14) NSF Projects Engage the Public in the Science of Birds and Bogs; (15) Physics Is Fun, Toys, and Games for Girls in Missouri; (16) Hands-on Science Curriculum Helps Students, Teachers, and Parents "Find Out"; (17) No Substitute for Well-Prepared Teachers; (18) Twenty-Percent of the Full-Time Physics Teachers Learn How To change the Way They Teach"; (19) Workshops Work for College and University Faculty; (20) Understanding Epileptic Seizures; (21) Blind Physicist Develops New Braille Technology for Science and Mathematics; (22) U.S. Senators Land NSF Project Selected as the 1992 Anderson Gold Medalist Winner; (23) Experimental Program to Stimulate Competitive Research (EPSCoR) Builds Science & Technology Competitiveness; (24) Urban Systemic Initiative: A Revolutionary Transaction; (25) Urban Systemic Initiative Chicago Planning Award: "What Was, Will Not Be"; (26) Statewide Systemic Initiatives Program Having Major Impact on States; (27) New Rural Initiative Completes the Educational Systemic Reform Trilogy; (28) Mississippi AMP Program: Making a Revolutionary Difference; and (29) Inventing Systemic Evaluation: The Bottom Line of EHR Program Evaluation. (ZWH)

NSF NOW

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Foundation for the Future

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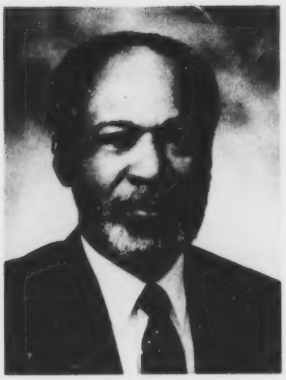
NATIONAL SCIENCE FOUNDATION
DIRECTORATE FOR EDUCATION AND HUMAN RESOURCES

The goal of the Education and Human Resources (EHR) Directorate of the National Science Foundation (NSF) is long-lasting and far-reaching improvement of the American educational system. From cradle to grave, learning is a lifetime proposition in today's world of fast-forward technologies. To adopt a phrase of my colleague, Labor Secretary Robert Reich, EHR has become a strategic broker, bringing together those who have identified the problems with those who have the resources and the skills to solve them. EHR provides the money to launch new projects and serves as a catalyst for new ideas and new approaches.

Education is at the core of what the National Science Foundation does. One cannot separate education from research. Research stimulates curiosity, creating a continued learning and exploration environment for all sectors of society and across the whole spectrum of age groups. That is central to the NSF mission.

Neal Lane
Director
National Science Foundation



What have we done for education lately...

During the last several years, there has been a rapid growth in the budget of the Education and Human Resources Directorate. The accompanying expansion of activity has taken place within the context of careful attention to strategy that will permit effective use of the increased programmatic resources. More specifically, NSF has taken the position that resource acquisition and new programming must be coupled with defined outcomes and results — a literal and profound change in the basic paradigm. This accommodation acknowledges the shift from inadequate, insufficient, and perhaps even ill-defined objectives to emphasis on documentable measures of progress toward the achievement of specific goals for programs of appropriate scope and scale. In these efforts, we are responding to the challenges of the present and the future in a manner that entails a quite fundamentally different order of resourcefulness and productivity expectations.

NSF has articulated a systemic approach to educational reform. It is an approach that permits the alignment of projects and activities and supports the establishment within the field of unifying policies and structures. NSF's Statewide Systemic Initiative, the Urban Systemic Initiative, and the Rural Systemic Initiative are programs that are carrying out this strategy. Additionally, large-scale curriculum projects have enhanced the impact of EHR activities. These projects, coupled with strategies within the EHR Directorate to effectively coordinate all our projects—large and small—within a given geographical region, are accompanied by both the education of classroom teachers in the use of new materials and the teacher collaboratives that address teacher preparation in an interinstitutional framework. In this publication, we present some of our activities/projects that are

- Changing the Curriculum and the Classroom
- Promoting Science to Students and the Community
- Enhancing Teachers and Their Craft
- Acting Systemically

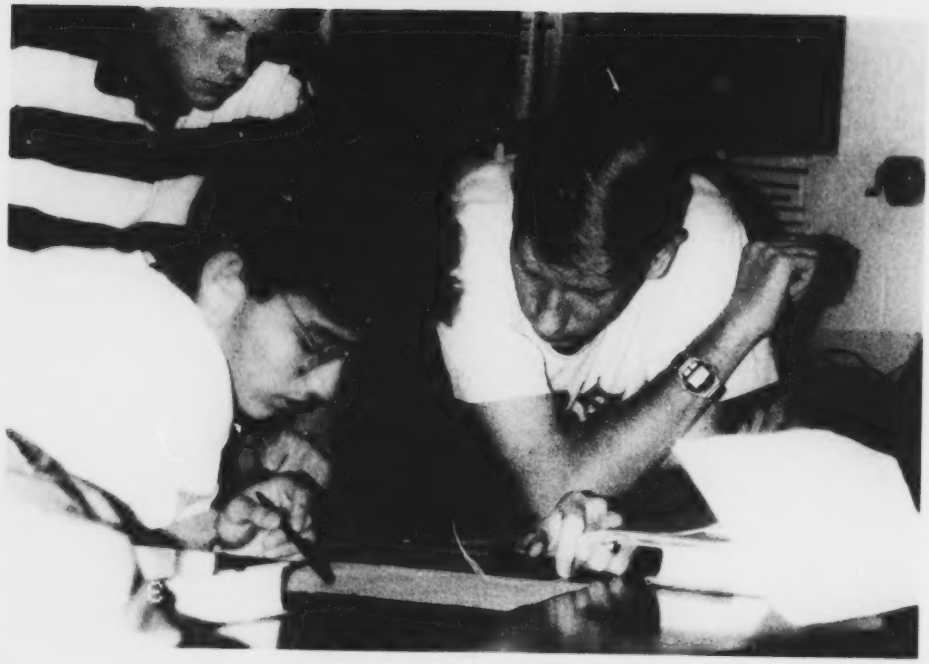
with specific emphasis on their individual and collective impacts.

The activities described here make clear the leadership niche that NSF's Education and Human Resources Directorate has established in the reform of science, engineering, mathematics, and technology education. The aforementioned achievements notwithstanding, future efforts must ensure the systemic objectives are fully realized and rapid progress is being made in such instances as innovation transferability, sustainability, full implementation of math/science standards based on instructional innovations, equitable participation by all students, and enhanced project design informed by research and practice.

Moreover, it is vital to recall that while major gains being made in local communities or individual projects are important, they do not equal a national enterprise. What is needed is a mechanism to ensure that the enterprise becomes nationwide. If we can effectively conjoin individual experiences, outcomes, knowledge bases, programs, and resources, the nation will be afforded a reasonable opportunity to address an exceedingly complex problem whose resolution will further increase the quality of life for all its citizens.

Luther S. Williams

Luther Williams
Assistant Director
Education and Human Resources Directorate
National Science Foundation



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Interactive Math Program Restructures 9–12 Math Education

Forty-thousand students in 56 schools throughout the country are part of a restructured secondary-school mathematics curriculum that works for all students. The Interactive Mathematics Program (IMP) began development of mathematics curriculum for all students in grades 9–12 in 1990, with 3 pilot schools in the San Francisco Bay area. IMP has now spread to half of California and across the country. Preliminary data show IMP's effectiveness. While roughly half of California high school students opt out of mathematics each year after the ninth grade, students who begin the IMP in ninth grade generally stay with it for all four years. In addition, comparisons of data over the past four years of the project indicate that IMP students perform better on SAT tests than non-IMP students. Though the program developers do not believe standardized tests measure true student performance, they realize that many of their students still need to take SAT exams if they want to go to college. More and more students may be on their way to college with IMP as a background.

Each year of the IMP curriculum is built around substantial complex problems. The problems are in the areas of algebra, geometry, trigonometry, probability, and statistics, each of which interconnects with one another and their applications. Students are challenged to actively explore open-ended situations, experiment with examples, look for and articulate patterns, and make and test conjectures in a way that closely resembles the work of mathematicians, scientists, and workers in industry.

IMP is one of 12 mathematics curriculum projects funded by NSF's Instructional Materials Development Program in the past four years to provide comprehensive multi-year mathematics curriculum materials for students and teachers K–12 based on the National Council of Teachers of Mathematics Curriculum Standards. Another funded performer, TERC (Technical Education Resource Center), produces materials that use the popular Used Numbers units developed by TERC and published by Dale Seymore, a division of Addison-Wesley, as a base for the new comprehensive curriculum for grades K–6. The "texts" for grades three and four will come off the presses in March 1994. **More than 33,000 teacher units of the six Used Numbers Modules have been sold and more than 3.5 million students have used them since 1990.**

The Instructional Materials Development Program's primary goal is the development of instructional materials appropriate for students of all interests, backgrounds, and abilities; at all levels (pre-K–12); and in all areas of science, mathematics, and technology. The program directs attention to the components of assessing student understanding of concepts and processes. It supports 20 assessment projects that look at all aspects of low- and high-stakes testing. **Widespread implementation of new curriculum materials funded by NSF is a high priority.**

In 1993, approximately 12 percent of the 42 million K–12 students across the country used mathematics and science curricula developed through the Instructional Materials Development Program during the past five years. It is estimated that these numbers will rise rapidly over the next few years as the new curricula near completion.

More than 33,000 teacher units of the six Used Numbers Modules have been sold and more than 3.5 million students have used them since 1990.

Algebra I Project Sparks Citywide Mathematics Curriculum Reform

The Algebra I initiative of the Science, Engineering, and Mathematics Precollege Preparation (SEMPREP) program in Baltimore, Maryland, which is supported by NSF's Comprehensive Regional Centers for Minorities (CRCM) program, led to major changes in the mathematics curriculum in the Baltimore City Public School (BCPS) system. The need for change in basic mathematics and science curriculum in public schools nationwide is evident. However, the implementation of successful innovations in classroom activities has been slow, often meeting resistance from both teachers and administrators. **In 1992, less than 5 percent of seventh graders and less than 25 percent of eighth graders in BCPS were enrolled in algebra courses** that are viewed as "gatekeepers" for higher level mathematics and science.

In September 1992, the West Baltimore Middle School, under the auspices of the CRCM program at Morgan State University, piloted the Algebra I project. The CRCM program provided classroom materials, workshops for teachers and parents, tutors for students, guest speakers, and field trips. Nearly 500 students in the eighth grade were enrolled in the middle school algebra project in 1992–93, along with eight mathematics teachers and department administrators. Teachers received staff development, so that sixth and seventh graders could be prepared for the eighth grade. Tutoring for participating students was provided by engineering and mathematics majors at Morgan State University. Textbooks, which students could carry home, were also provided. Parents were provided orientation sessions to learn about their children's involvement in this special project. All agreed to their children's participation.

Results to date are very encouraging: nearly 100 percent of the students completed the course; grades were higher in the course than in the science courses and equal to those in English and language arts; and the overall attendance for eighth graders improved. The principal of the West Baltimore Middle School believes that the attention given to students in the special project improved their self-esteem and led to better school attendance.

The success of the pilot program led to the establishment of a school board policy requiring algebra for all eighth grade students in the Baltimore Public Schools, beginning in school year 1993–94. Approximately 8,000 students are now enrolled in Algebra I in the Baltimore City Public Schools. According to Dr. Maurice B. Howard, Assistant Superintendent of Curriculum Instruction, "Our goal is to ensure that all of our graduates pursue mathematics through calculus and science through physics."

The "rivers curriculum" challenges students in 23 states to integrate concepts of chemistry, biology, earth science, geography, and language arts.

A River Runs Through It: Interdisciplinary Curriculum in 250 Schools

The Illinois Rivers Project's interdisciplinary "rivers curriculum" **challenges students in 23 states to integrate concepts of chemistry, biology, earth science, geography, and language arts.** Students complete measurements, analyze data, and discuss that data's significance in decision-making and problem-solving formats. In addition to the coursework, a congress is held each year where students present their efforts, which are then published in a student-authored publication, *Meandering*. The Project also sponsored a River's Curriculum Training Session for nearly 200 teachers in 1993. Initiated in 1990 with 8 schools, the Illinois Rivers project has grown to include more than 250 schools in the central United States. The interdisciplinary curriculum developed by the project is designed to apply to any river in the world.

The Illinois Rivers Project has gained recognition by earning various awards, including two state and national merit awards from the Soil and Water Conservation Society. The Illinois Department of Conservation presented the Rivers Project with two Take Pride in America awards, and the Department of Interior awarded the Project with a national Take Pride in America award. The Project has received two Illinois Department of Energy and Natural Resources ILEED awards for Energy Achievement, a Region V award from the USEPA for the President's Environmental Youth Award, and a national USEPA award for Excellence in a Group Project. The Project received a merit award from the Keep America Beautiful National Awards Program, a Chevron Conservation Award, and the Outstanding Achievement Award for 1993 from the Renewable Natural Resources Foundation.

This project is an example of an instructional materials development project that produces modules that can be added to any science curriculum in a school.

Calculus Leading the Way

"[I] actually understood a large part of the information involved in first semester calculus. Notice that I said 'understood,' not that I simply memorized the concepts."

University of Arizona calculus student talking about the Core Calculus Consortium.

Students are learning calculus using the "Rule of Three," exploring graphically, numerically, and analytically as part of the Core Calculus Consortium Project. Through these multiple approaches and the use of technology, students understand the mathematics and better apply it. NSF funding has been essential to support critical features that have led to the success of the project: development of materials radically different from those which were being developed through commercial publishers; involvement of diverse institutional types in the development and testing of the materials; and faculty workshops to introduce the fundamental changes in teaching and student learning.

The initial consortium of eight institutions led by Harvard University included the University of Arizona, Colgate University, Haverford-Bryn Mawr Colleges, University of Southern Mississippi, Stanford University, Suffolk Community College, and Clemsford High School. **The materials are now being used at approximately 315 colleges and universities and 35 high schools.**

Although the Core Calculus Consortium materials are by far the most widely adopted of the calculus materials developed with NSF support, other projects have led to the publication of texts and other materials. The purpose of the NSF Calculus and Bridge to Calculus Program is to foster the reform of calculus instruction on the national level. **A recent study estimates that in Fall 1993 over 125,000 students, or about 22% of the total calculus enrollment in our nation's colleges and universities, are enrolled in courses using approaches developed through the national calculus reform movement.**

Through NSF support, numerous calculus materials including texts, laboratory manuals, faculty handbooks, and software packages have been commercially published.

University of Illinois
at Urbana-Champaign
Calculus andMathematica
(Addison-Wesley)

St. Olaf College
Calculus from Graphical, Numerical, and Symbolic Points of View
(Saunders College Publishing)

Oregon State University
Calculus
(PWS-Kent)

Purdue University
Calculus, Concepts and Computers
(West Educational)

Harvard University
Calculus
(John Wiley)

Duke University
The Calculus Reader
(D.C. Heath)

University of Iowa
Calculus Using Mathematica
(Academic Press)

Five Colleges, Inc.
Calculus in Context
(Freeman)

Air, Earth, Fire, Water—
What do these have to do with modern chemistry?

Those alchemical "elements" may well become the basis for an exciting modern approach to the freshman chemistry laboratory. At the University of California, Berkeley, students are actually using the soil from their community, the water from local ponds, and the air they breathe as a basis for learning chemistry. The Environmental Chemistry Laboratory lets students work as "real" scientists do and at the same time illustrates the realistic societal issues that must be a part of science decisions.

The course is often called a "discovery laboratory" because students are presented with a question, then must propose answers and experimental approaches themselves rather than working through a dull "cookbook" procedure to simply verify some concept or data. The students actually go out into the community to sample sites that may be of environmental interest. For example, one site is a community play area where the students sample soil; another is a local pond where water samples are obtained. The protocol for significance in sampling plays a very important role as does the societal concerns about what is appropriate to look at.

The chemistry comes in when the students return to the laboratory. Working in groups, they decide what to test and how to do it. Chemistry and laboratory concepts must be learned to do this. The soil, for example, will be tested for lead and other potentially toxic metals. The water might be tested for pesticides, or salts, or a variety of other materials related to public health.

Finally, students develop their own special topic project. These projects require the students to use their knowledge of sampling, site assessment, laboratory techniques, and chemistry principles, as well as cooperate with others in the class. Communication skills are developed through a final oral and written report to the class.

Is it working? So far the course is oversubscribed. Students admit that this environmental course requires much more work than the standard freshman chemistry laboratory, but they say it is worth it.

Educating the Technical Work Force for the 21st Century

Fact:
For the United States to be competitive in the world market, the technical work force of the United States must be better prepared than that of other industrialized countries.

The recently initiated Advanced Technological Education (ATE) Program supports improvement of the technical work force.

POTENTIAL IMPACT: Today there are almost 4,000 engineering and science associate degree programs in the United States; 62 percent of the nation's 1,325 two-year colleges have at least one of these programs.

In 1993, there were about 100,000 students enrolled in these programs; however, due to the increased industrial demand for graduates of such programs, it is expected that the number of students in these programs will triple in the next five years.

Queensborough Community College's highly successful project employs a comprehensive strategy to improve student mastery of engineering technology and to heighten student academic participation and achievement. These laboratory-driven courses emulate an industrial work place and thus enhance academic and employment opportunities for technicians being educated for the high-performance work place of advanced technologies. Because employers have increased academic hiring requirements commensurate with the revolutionary developments and growth of emerging computer-related technologies, industrial partnerships with business and industry ensure that the program is developing to provide students access to the newest equipment and information. Close ties with other two-year and four-year colleges in the City University of New York (CUNY) system and the New York Alliance for Minority Participation as well as secondary schools make this program a part of a continuum of education for technical students.

Activities in two laboratories are being restructured to foster improvements in the mastery of laboratory and computer skills in electronics. Courseware is being developed so that students use computer software to simulate and experiment with electric circuits. On-line, interactive materials aid students in designing circuits and in setting up and using equipment safely. These science and technology laboratories are equipped with data acquisition systems, automated test equipment, networked computer workstations, interactive multimedia courseware, data access capabilities, and interactive on-line laboratory manuals and informational resources. Future directions for the program include courses in telecommunications, data communications, networking, laser optics, and electrical and computer control systems.

A key feature of the new program is faculty enhancement. Workshops are being conducted to introduce the faculty who teach in these emerging technology programs to hardware and software for instructional and professional use. During the past two years, Queensborough sponsored more than 10 workshops to help prepare faculty in the New York area to teach in this new environment.

Promoting Technology Transfer

Maintaining our nation's leadership in creating advanced technologies depends on achievement in key areas, one being the rapidly developing area of machine tool research. To achieve this leadership, the Mechanical Engineering Department at the University of Florida is developing a model for restructuring its Ph.D. program. Industrial internships, which will be provided under the guidance of a Machine Tools Research Center Advisory Board that has academic and corporate membership, have tremendous potential for promoting more effective technology transfer between the university and industry. In addition, since some countries support machine tool research more strongly than the United States, student exchange agreements with European and Japanese research centers will afford unique opportunities for students to gain exposure to the diverse research activities that occur in other countries.

Support for this activity at the University of Florida is provided from the Foundation's Graduate Research Traineeship (GRT) Program. The grant will support five graduate traineeship positions that will cover a wide spectrum of interdisciplinary research areas (including high-speed machining, advanced control systems, sensor integration, and intelligent machine tools), ensuring that the future industrial benefit of the program is maximized and that an oversupply of Ph.D.s focused on one narrow area is avoided. This GRT support is a key component in the implementation of the three-phase program that will serve as the model.

This GRT grant is one of 42 awards made in 1993 for the support of graduate students in specific areas critical to strengthening the nation's science and engineering competitiveness. The program uses very selective targeting of student support to leverage the production of new graduates at the advanced levels of academic study. Traineeship awards in 1994 will focus on several priority subdisciplines, including human interface design for access to computers and networked information, environmentally conscious manufacturing, and coastal ocean processes, to name a few.

Graduate Fellowship Program Links with Oak Ridge

NSF's Graduate Research Fellowship Program has initiated a major new contract with the Oak Ridge Associated Universities, Inc. (ORAU). Under the competitively-awarded contract, estimated to be worth approximately $7.5 million over three years, ORAU will carry out the processing and evaluation function for NSF for an estimated 9,000 applications annually.

The Graduate Research Fellowship Program is one of NSF's two original programs, the other being its basic research grants. **Since 1952, more than 30,000 of the nation's most outstanding young scientists and engineers have been awarded support for advanced study and research. Twelve of these individuals have received the Nobel Prize, and their numbers are liberally included among all measures of scientific and academic leaders.**

Oak Ridge Associated Universities is a national membership organization of colleges and universities with a long association with the Department of Energy, for whom it manages a wide variety of educational and research activities involving academic institutions. A new component of ORAU reporting directly to its president has been established under the NSF contract. The activity will involve approximately 400 scientists and engineers annually who will be engaged to advise ORAU in the evaluations of applications. The new association with ORAU follows a similar and very successful 42-year relationship with the National Research Council.

Both NSF and ORAU look forward in this new relationship to exploring the many new technological vehicles on the information superhighway in all aspects of making application for federal fellowship support, the transmission of supporting materials, application evaluation, and follow-up of career progress and achievement.

The Graduate Research Fellowship Program supports about 2,400 graduate students per year. These students, just under 1 percent of the nation's full-time science and engineering graduate students, comprise the best and brightest of the nation's young talent. Their fellowships provide them the maximum flexibility to choose their institutions, field, and mentors to prepare for research leadership in the next generation.

Hampton University Spearheads Increased Production of Doctorates in S&E by HCBUs

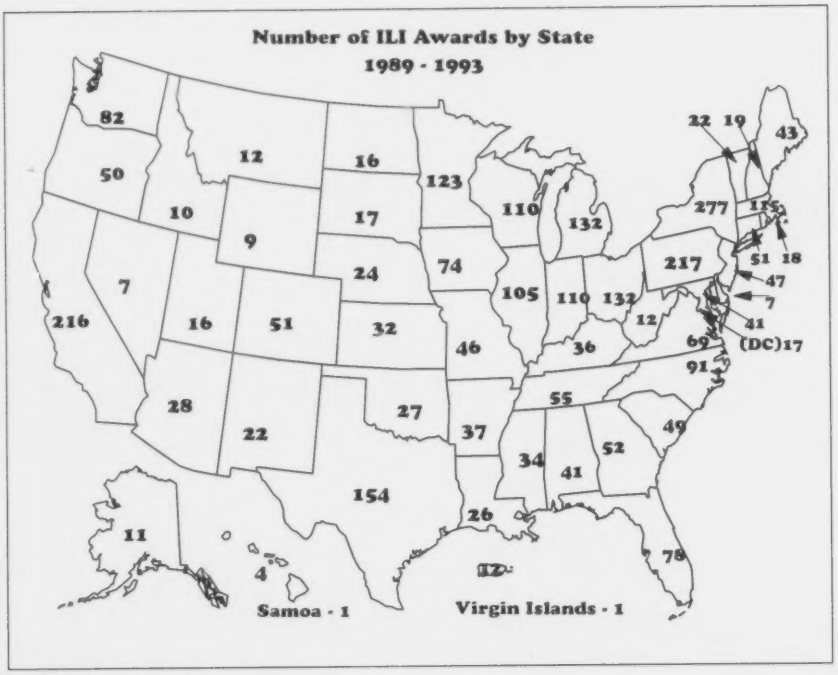
Between FY 1988 and 1993, this program impacted the production of nearly 2,300 baccalaureate degrees, 340 master's degrees, and 50 doctoral degrees earned by minorities in science and engineering.

Hampton University, one of five Historically Black Colleges and Universities (HBCUs) participating in NSF's Minority Research Centers of Excellence (MRCE) Program, announced the establishment of a doctoral program in Physics for academic year 1993–94. This will be the first doctoral degree program at the university and the first doctoral degree in high-energy physics at a Historically Black University in Virginia. This doctoral program will provide a research environment that encourages the pursuit of original ideas and concepts that contribute to the body of knowledge in physics; provide a source of scientifically trained personnel for local, state, and national needs; and provide minority doctorates, who are underrepresented in the discipline.

Begun in FY 1987, the MRCE Program now supports a total of eight Centers, at Alabama A&M University, Clark Atlanta University, The City College of New York, Hampton University, Howard University, Meharry Medical College, the University of Puerto Rico, and the University of Texas at El Paso. **Between FY 1988 and 1993, this program impacted the production of nearly 2,300 baccalaureate degrees, 340 master's degrees, and 50 doctoral degrees earned by minorities in science and engineering.** In addition, nearly 6,000 precollege students have participated in special outreach programs over the same period.

The Hampton development is a result of the initiation of several major research relationships, including the establishment of the MRCE and the signing of a Memorandum of Understanding (MOU) between Hampton University and the Continuous Electron Beam Accelerator Facility (CEBAF) in Newport News, Virginia. During the 1991–92 academic year, a $5 million grant, over a five-year period, was received from NSF to form the Nuclear/High Energy Physics Research Center of Excellence. The Center allowed the expansion of the work of faculty, and undergraduate and graduate students, as well as the formation of research alliances with both minority and majority institutions. The MRCE award is renewable for an additional five years if the Center meets all of its goals of its current five-year cooperative agreement.

Isolated Colleges Ride the Information Highway



Five small colleges in the Appalachian region of Virginia, West Virginia, North Carolina, and Kentucky now have access to the Internet, a system of computer networks that forms part of the worldwide "Information Highway." Through an NSF grant to the University of Kentucky Appalachian Scholars Program and equipment donations from AT&T, each of five colleges has a high-speed connection to the Internet and 18 connected computers for faculty and students to use in course work and research, including cooperative projects among the colleges and with other colleges and universities around the country. In addition, students and faculty can work with large files of data that are accessible on the network.

The five colleges are Cumberland College, Williamsburg, Kentucky; Campbellsville College, Campbellsville, Kentucky; Lees McRae College, Banner Elk, North Carolina; Ferrum College, Ferrum, Virginia; and Wheeling Jesuit College, Wheeling, West Virginia.

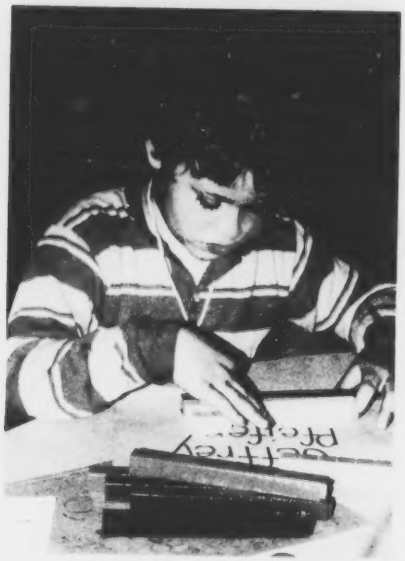
The University of Kentucky is providing training, maintenance, software support, and network monitoring.

The computers are most heavily used for electronic mail and in computer science and mathematics courses. Electronic mail allows easy, almost instantaneous communication among faculty at the schools. It allows faculty and students in small departments to become more active in a wider community and to interact with colleagues at other colleges with similar interests.

The mathematics work is associated with the NSF-supported calculus reform project at the University of Kentucky, and the computers are being used to do symbolic manipulation; in computer science, students are studying the operation of the local network as well as the operation of the computers themselves. There is also some use in biology, psychology, chemistry, physics, and business courses. Projects developed at one school are often applicable at the others since the equipment is the same, and they can be easily exchanged over the network.

The Undergraduate Instrumentation and Laboratory Improvement (ILI) program, which funds this project, has current projects in all 50 states and 4 territories involving about 25 percent of the 2- and 4-year colleges and universities in the United States.

CGI: "You Sort of Take What They Know and Build on from There."



Results from research on young (K-3) children's mathematical thinking indicate that they possess intuitive, analytic modeling skills. However, as students move through the formal education system, they abandon this fundamentally sound, general problem-solving approach for the mechanical application of arithmetic and algebraic skills.

Cognitively Guided Instruction (CGI) started as a research project, funded by the Research on Teaching and Learning Program, to investigate the impact on teachers and their students, grades K–3, of research-based knowledge about children's thinking. CGI teachers learn how research-based knowledge of children's mathematical thinking can help them learn about their own children. Each teacher uses that knowledge to create a unique teaching and learning environment in which each child's thinking is important and respected by peers and teachers.

Children in CGI classrooms spend most of their time solving problems—usually problems that are related to a book the teacher has read to them, a unit they may be studying outside of mathematics class, or something going on in their lives. They are not shown how to solve the problems. Instead, each child solves them in a way that she or he can. Each child decides how and when to use the materials available to them or when to solve the problem mentally. Children report their strategies to the whole class. The teacher and class listen until they understand the problem solutions. Teachers then make decisions about what each child knows and how instruction should be structured to enable that child to learn.

Research on CGI teachers indicates that the degree of knowledge that teachers have about CGI and their children's learning is correlated with what their children learn in mathematics. Compared with children in traditional classrooms, those in CGI classrooms

- learn much more than has usually been expected of them;
- report more confidence in their ability to do mathematics;
- demonstrate a higher level of mathematical understanding; and
- are more flexible in their choice of solution strategies.

Perhaps Susan Gehn, a first grade CGI teacher, put it best:

A CGI classroom is where you build on the math knowledge of your children according to what they know... You don't build objectives that say they should be doing this, this, this, and this. You sort of take what they know and build on from there.

Science Comes to Television: "Bill Nye the Science Guy" and "CRO" with School Kits Too

While many children's television shows are criticized for being half-hour toy commercials, two science series for youth, broadcast on commercial television and funded by NSF, offer children more. "Bill Nye the Science Guy," **a syndicated series airing in 98% of the television markets in the U.S.,** gets support from NSF and the Disney Foundation. "CRO" is broadcast nationally by ABC at 8:00 a.m. on Saturday mornings and was developed by the Children's Television Workshop through funding by NSF. Both series reach youth where they spend a large chunk of their time—watching television. The programs entertain and hold children's attention, but also present science and technology.

Both projects include multiple outreach activities. "Bill Nye the Science Guy" has provided teacher kits to every fourth-grade science teacher in public and private schools nationwide. The project will also give viewers who request them free science kits that will enable them to engage in science activities at home. "CRO" distributed over 3.25 million copies of supporting materials to children at home and in after-school settings. These materials included a 20-page, four-color "CRO" science comic book; a two-sided, pull-out science activity poster; two sets of science activity cards; and an interactive "CRO" science-puzzle in CTW's 3-2-1 Contact magazine.

These two series have been highly acclaimed and are quite successful in reaching their goals. National ratings of the series indicate that **"Bill Nye the Science Guy" reaches over 1,220,000 households weekly and "CRO" reaches more than 1,790,000 households weekly.** While viewer demographics indicate that the largest audiences are children, both series have also attracted surprisingly large adult audiences. "Bill Nye the Science Guy" has been especially effective in attracting family viewing.

NSF-supported media activities, including Square One TV, 3-2-1 Contact, and IMAX films, etc., are viewed by more than 60 million people.

180 Students Demonstrate the Art and Science of Engineering—Some Even Invented Equipment for the Disabled

Engineering is the art and science of applying pure science to the construction of engines, bridges, buildings, mines, roads, chemical plants, space stations, and more. The engineer is an adventurer, an innovator, a builder, a creator, and above all, a problem solver. The 180 students became all of these in the summer of 1993 in the Cooper Union for the Advancement of Science and Art, Albert Nerken School of Engineering Research Internship Young Scholars Program. Of these 180 students, 76 were female and 58 belonged to a minority group.

The Young Scholars Program provides high-ability and high-potential students in grades 7–12 with knowledge and self-confidence in science, mathematics, and engineering. Students gain an awareness of careers in mathematics, science, and engineering, as well as research experiences in industries, colleges, and universities throughout the country. **Each summer, approximately 7,800 students across the country take part in similar Young Scholars Programs.**

This program changes the way students think about science and the way they look at careers in engineering. Student Diana Perez said, "this program has encouraged me to major in engineering in college [and] has also given me a real sense of what engineering is and its applications in real life."

Students learned first-hand about the problem-solving skills engineering requires. A group of seven students determined that a device to aid persons with disabilities in brushing their teeth is uncommon. They found a self-rotating toothbrush, but discovered that those with certain disabilities may not be able to hold it. Consequently, this group developed a toothbrush with a motion controller, driven by a computer, that was supported on a platform. Other groups of students worked on the development of more efficient workplace designs, automatic page turners, earthquake structural designs, and other equally challenging projects.

Students in The Global Laboratory Make Their School a Safer Place

The Global Laboratory II enhances student learning of science by focusing on the interdisciplinary applications of the natural and earth sciences related to global change and ecological issues. The students in the Global Lab at Pease Middle School in San Antonio, Texas, took this mission to heart. Mindful of complaints about poor air quality throughout the school, the Global Lab students conducted a schoolwide survey of faculty and students, then followed strict protocols for measuring CO_2 levels. They found them to be as high as 2,100 ppm indoors and 350 ppm outdoors. These measurements and survey results were presented to the school board, which dispatched four environmental control officers to investigate. The Global Lab teacher reported what ensued on the computer network.

The EPA checked the findings and confirmed the problem. The school's ventilation system was repaired, reducing the ozone level. As reported in the Technical Education Research Center (TERC) newsletter, "Hands On!" (Fall 1993), "Not only had the students conducted real scientific research, their findings had made a true difference in their lives and in their community."

Many other students may be making differences in their own schools, for at the beginning of the 1992–93 school year, the Global Laboratory II project, supported by the Applications of Advanced Technologies program, had 100 participating schools throughout 18 countries. The objective of the project is to field test the tools developed through computer-based networks (teleconferencing on the international EcoNet), which bring together students as scientists under the mentorship of teachers and researchers. Work in the current phase of the Global Lab will create teacher support strategies and curricular materials, apply technologies to allow measurements in experimental global ecology, and assess the performance of students as researchers.

Global Lab will create teacher support strategies and curricular materials, apply technologies to allow measurements in experimental global ecology, and assess the performance of students as researchers.

Above: Students at Bradford College in Massachusetts read the temperature of the ambient air and prepare to telecommunicate their results to other participants in the NSF funded Global Lab Project at TERC.

Right: Students of School 520 in Moscow evaluate the air outside their school as part of the NSF funded Global Lab at TERC.

NSF Projects Engage the Public in the Science of Birds and Bogs

Two NSF projects demonstrate how the public can participate in science outside of traditional venues.

The Cornell Laboratory of Ornithology is getting the help of more than 25,000 people in its research of birds. It has established three experiments that will involve the public at large. (1) The Bird Seed Preference Test, which will involve over 10,000 students and adults, is aimed at looking at the preferences of birds for various types of seeds. The data will be examined to determine the habits of the various species and to identify if there are regional differences. Studies on this topic and on this scale have never been done before. (2) The Project Tanager Study is a research project that looks at the breeding success of four species of North American tanagers. Results of this study will contribute to our understanding the impact of forest fragmentation on birds and other wildlife. (3) Project Pigeon Watch will involve inner city children and their families in ornithological research activities to provide greater understanding of the behavior and morphology of urban birds. Study sites are being established in Syracuse, Washington, D.C., New York City, Boston, Atlanta, San Francisco, and San Diego, among other places, and collaborations with local community groups will be made to facilitate the children's involvement.

A second NSF project is "Mysteries of the Bog," a traveling museum exhibit which interactively engages visitors in learning about the poorly understood bog habitat by examining details of its natural history, archaeology, history, and economic value. The peculiar physical feature of bogs has led to a popular view of them as fearful and unhealthy places. This exhibit shows the elaborate and intricate natural relationships and explores the relationship between humans and bogs in both modern and prehistoric times. A better understanding of bog ecology, the role bogs play in the maintenance of biodiversity, and the historic and economic relevance of bogs will counter the trend of destruction of these important areas.

The 3,000-square-foot exhibit, developed by the Museum of Science in Boston, opened on November 2, 1993, and will next travel to museums in eight major U.S. cities including Philadelphia, Los Angeles, Chicago, Fort Worth, and Charlotte. As many as six million people will visit the museums to see this exhibit.

These projects are supported by the Informal Science Education Program and address the program goals of stimulating youth to be excited about science, math, and technology; reaching traditionally underserved audiences; improving the science literacy of children and adults; and promoting effective museum-school linkages.

Physics Is Fun, Toys, and Games for Girls in Missouri

An NSF-funded project at the University of Missouri at Columbia is bringing more young women into scientific careers, impacting the existing dearth of women in these fields. The project has developed and is implementing an experiment-based, hands-on program that introduces young women to the concepts of physics through the development of games, toys, art projects, and laboratory experiments. Dr. Meera Chandrasekhar, professor of physics, believes "If these young girls can see that science is fun, they have a greater likelihood of pursuing future involvement in the sciences, perhaps even scientific careers."

During the four-week program, groups of 40 fifth- and sixth-grade girls meet twice a week after school at two elementary schools in the Columbia Public School District. During the hour-and-a-quarter sessions, the young women conduct basic experiments in sound and optics. The experiments increase in complexity as the program progresses; however, the students are allowed to work at their own pace. Forty different experiments are available, and, because they are working in pairs, every student has ample opportunity for hands-on participation. Although the program is limited to girls at this point, the experiments are gender-neutral and could be useful for young men as well.

Many of the experiments involve making various types of objects and toys that illustrate the principles of optics. The goal is to help the young women understand what makes the toys work. By having something tangible to take home, it is hoped that the young women share their new knowledge with family and friends, creating more enthusiasm for the subject.

The project has been publicized to a wide audience of teachers and administrators at a regional science and math conference and the National Science Teachers Association (NSTA) Convention. An unexpected result of the project has been increased enrollment in a summer teacher's workshop on optics. Teachers have asked to borrow equipment from the project for use in their classrooms and have asked Dr. Chandrasekhar to speak to their classes.

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The project has been funded for a second year to expand the types of science introduced to the students and to include young women of a broader age range.

Funding for both projects was awarded through the Model Project program, part of the newly restructured EHR Activities for Women and Girls. The Model Projects provide funding for short-term, highly focused activities that improve the retention of females in science, engineering, and mathematics (SEM). Experimental Projects for Women and Girls is a second funding opportunity that supports projects that create positive and permanent changes in academic, social, and scientific climates in order to allow the interest and aptitude women and girls display in SEM to flourish. The final funding area, Information Dissemination Activities, encourages the dissemination of strategies that improve the interest, retention, and advancement of women and girls in SEM or reduce barriers to the participation and achievement of this population.

Hands-on Science Curriculum Helps Students, Teachers, and Parents "Find Out"

"We will learn about seeds. What's inside a seed? We will find out. Does a seed have a bottom and a top? We'll find out. How can you be sure this is a seed? We'll find out."

(Student Journal Entry)

Pasadena's hands-on science curriculum successfully gets all the children and teachers in K–9 classrooms involved in science regardless of background or skill level. Being able to work with real, manipulative materials during science lessons helps students better understand abstract concepts. At the same time, the students become familiar with the scientific method, gain valuable problem-solving skills, and develop an appreciation for the creative aspects of science.

The Pasadena Unified School District (PSUD) elementary science program is supported by an NSF Teacher Enhancement grant that involves scientists from Caltech helping teachers feel comfortable and confident with their capability to teach inquiry-based science to young children. Working side by side with teachers on the hands-on materials, they model the process involved in scientific reasoning and experimentation. When appropriate, the scientists also contribute to discussions on scientific content as well as its relevance to contemporary scientific questions.

A recent workshop introduced parents and community members to what is happening in classrooms during science lessons, and how volunteers can support science activities both in and out of school. People who attended the workshop participated in active experiments from the third grade Scientific Reasoning kit, which is designed to teach students about variables. Parents, comparing and discussing the effects stretching and jumping have on a person's heart rate after exercising, shared the same enthusiasm and excitement that their children experience every day in Pasadena Public Schools.

The Pasadena Project is just one of many Teacher Enhancement projects throughout the country that are designed to enhance teachers' knowledge in both content and pedagogy and to help teachers become the agents of change in mathematics and science instruction. **In 1993, there were over 46,000 teachers throughout the country involved in projects similar to the Pasadena Project.**

No Substitute for Well-Prepared Teachers

Research on teaching effectiveness shows that there is no substitute for well-prepared teachers—they are essential. "...effective teaching behaviors are found to vary...While teachers' background in science was positively related to students' science achievement..." (*Indicators for Monitoring Mathematics and Science Education: A Sourcebook*).

The Maryland Collaborative is creating a challenging program that will serve as a national model for the undergraduate preparation of elementary and middle school teachers. The project, which is led by mathematics, science, and engineering faculty, centers on five themes:

- big ideas of the disciplines
- connections among the disciplines
- active learning experiences
- use of technology to learn concepts, solve problems, and conduct research
- field experiences

One of the first three Collaboratives funded, the Maryland Collaborative is a coalition of the University of Maryland — College Park, University of Maryland — Baltimore County, Bowie State University, Choppin State College, University of Maryland — Eastern Shore, Frostburg State University, Salisbury State University, Towson State University, Baltimore City and County Public Schools, and Prince George's County Public Schools.

This project typifies the goals of the Collaboratives for Excellence in Teacher Preparation Program, the principal aim of which is to support the design and implementation of teacher preparation programs that will produce K–12 teachers who demonstrate excellence in the teaching and learning of mathematics and science. The Collaboratives Program, designed to fundamentally ensure the requisite content and pedagogical competencies, is in its inaugural year with a five-year goal of **impacting more than 50 percent of new K–6 and 7–12 mathematics and science teachers annually.**

Division of Undergraduate Education
Maryland Collaborative for Excellence in Teacher Preparation

PARTICIPATING INSTITUTIONS
University of Maryland, College Park (LEAD)
Baltimore City Community College
Bowie State University
Choppin State College
Frostburg State University
Morgan State University
Salisbury State University
Towson State University
University of Maryland, Baltimore County
University of Maryland, Eastern Shore
Baltimore City Public Schools
Baltimore County Public Schools
Prince George's County Public Schools

Twenty Percent of the Full-Time Physics Teachers Learn How to Change the Way They Teach

More than 1,000 of the nation's 4,600 full-time physics teachers have changed the way they teach physics in high schools as a result of the American Association of Physics Teachers (AAPT) teacher enhancement projects that have created a cadre of physics resource teachers. Each of the projects achieves this by utilizing a cooperative team of outstanding high school physics teachers (Physics Teacher Resource Agents or PTRAs), a two-year college physics instructor, and a university physics instructor. The three components of each project include a two-week series of workshops conducted in the summer season with the hands-on skills of the PTRAs, a series of follow-up workshops during November and March of the subsequent academic year (a spaced learning approach that enables digestion and assimilation of concepts), and on-site visits to teachers' classrooms by the experienced physics teachers who provide participants with mentoring and assistance in implementing what they have learned. Participants show significant gains in concept mastery as measured by the nationally standardized AAPT/NSTA Introductory Physics Examination. Marked change in classroom instruction resulted, as evidenced by the 1,005 of the participants who have made extensive use of the new teaching techniques they've acquired in the program.

For example, PEP, a PTRA-guided Texas project, succeeded in enrolling 45% minority high school physics teachers and 41% women physics teachers in their program. This is a remarkable achievement for any teacher enhancement project and more so in physics, a field dominated by white males.

These teacher enhancement activities affect student performance; two of the participating Texas schools succeeded in placing in the top three of their respective school classes for the statewide University Interscholastic League competition in physics. This placement reflects the highest level achieved by either school, and is significant when one considers that there are 1,083 schools in the state that participate in the competition.

More than 1,000 of the nation's 4,600 full-time physics teachers have changed the way they teach physics in high schools as a result of the American Association of Physics Teachers (AAPT) teacher enhancement projects

Workshops Work for College and University Faculty

In 1993, the Undergraduate Faculty Enhancement program funded 80 projects for 4,400 faculty participants, who in turn reached more than 250,000 students in improved courses.

An evaluation shows that faculty participating in workshops sponsored by the NSF Undergraduate Faculty Enhancement (UFE) program find the experience highly worthwhile. They are introduced to new technologies or to technologies that they have never had the chance to try out. This results in both modified and entirely new courses. The result often includes a proposal to their institution, or perhaps to NSF, for new equipment for undergraduate laboratories.

These findings come from a program evaluation of UFE by an external evaluator, Westat, Inc. Such formal evaluations are increasingly important to NSF's education agenda. We must know how effectively NSF programs work for different constituencies.

The UFE programs supports activities that enable faculty members to gain experience with recent advances and new experimental techniques in their fields and with ways of incorporating these into undergraduate instruction. Projects are regional or national in scope and typically consist of hands-on workshops or short courses, along with follow-through activities. **In 1993, the UFE program funded 80 projects for 4,400 faculty participants, who in turn reached more than 250,000 students in improved courses.**

These figures include the National Chatauqua Workshop Program which offers over 80 short courses each year to some 2,000 faculty participants in locations across the country.

A major feature of UFE is regional coalitions among two- and four-year institutions. These coalitions and other workshops often serve as vehicles for dissemination and adaptation of model courses and materials developed under other NSF programs in curriculum and laboratory improvement. For example, faculty of community colleges and universities in the Chesapeake Bay area joined forces through a UFE workshop to develop field activities and laboratory exercises using the Bay and its watershed to illustrate topics in ecology, chemistry, and biology. Their resource book is complete with a floppy disk for a self-directed field trip to the Baltimore Aquarium.

Understanding Epileptic Seizures

Professor Karen Gale of Georgetown University Medical Center has made two recent medical advances, one relating to epileptic seizures and the other to learning and memory. Dr. Gale has located a discrete site in a monkey brain from which seizures could be triggered that closely resemble human complex partial seizures or temporal lobe seizures. She also identified a specific region of the monkey brain where focal application of a drug caused marked impairment of memory. Dr. Gale performed this work at the University of Washington as a grantee in the NSF Visiting Professorships for Women (VPW) Program. While at the University of Washington, Dr. Gale did more than research. She provided guidance and encouragement to women pursuing research careers by developing and presenting a workshop series on "Survival Skills for Women in Science." She held the workshop again after her return to Georgetown University and intends to present it on a regular basis in the spring term of each academic year.

Since returning to her home institution, Dr. Gale has been elected to the Professional Advisory Board of the Epilepsy Foundation of America (EFA) and has been appointed to the committees responsible for the review of fellowships and research grants for both the EFA and the American Epilepsy Society. She has also been elected as Director of the new Interdisciplinary Neuroscience Graduate Program at Georgetown University. **Her VPW experience played a major role in her decision to compete for this leadership position.**

This award was one of 22 VPW awards made in 1992 to promote the research careers of women scientists and engineers and to provide greater recognition for them in the nation's leading research universities. Grantees spend approximately 70 percent of their time on research and the remainder on developing visibility as role models to both male and female students and faculty.

Over 300 VPW awards have been made since this program was initiated in 1982.

NSF Triples Fellowship Support of Women in Engineering

Expect to see an increase in women engineering faculty in the late 1990s. Through the initiation of Women in Engineering components in both the Graduate Fellowship and the Minority Graduate Fellowship Programs in 1990, NSF has addressed the increasingly visible lack of women Ph.D.s in engineering, which lags behind many other areas of science. **In a joint initiative with the Directorate for Engineering,** 80 additional awards per year are supported for women engineering applicants. In its first four years, it is estimated that the number of fellowships for women engineers was nearly triple what would have resulted from "business as usual" in that period: **560 instead of the predicted 190.** These awardees will be completing their Ph.D. study in the mid-90s and are expected to have a significant impact on the engineering faculty ranks.

Blind Physicist Develops New Braille Technology for Science and Mathematics

Four years ago, Dr. John Gardner of Oregon State University went blind suddenly. Dr. Gardner, who has received NSF funding in physics and materials sciences for many years, needed a way to continue his scientific work. A computer equipped with a speech synthesizer enabled him to access text, but not the mathematic equations that were crucial to his research efforts. This led to **Dots+**, a project that combines dots and graphics in a way that is easy and intuitive for the blind to read and that can be applied to essentially all technical literature.

Currently, students and professionals who are blind have limited access to mathematics. An audio presentation typically requires the listener to retain and organize too much information mentally. Literary braille consists of dot patterns arranged within a two-by-three cell, which allows for too few permutations to provide the user with an adequate library of symbols for higher mathematics. Braille mathematics symbology, therefore, requires two or more cells to represent many symbols, and a braille line is normally limited to 40 cells. Consequently, it is often impossible to write mathematical equations in a spatial format typically used in printed text.

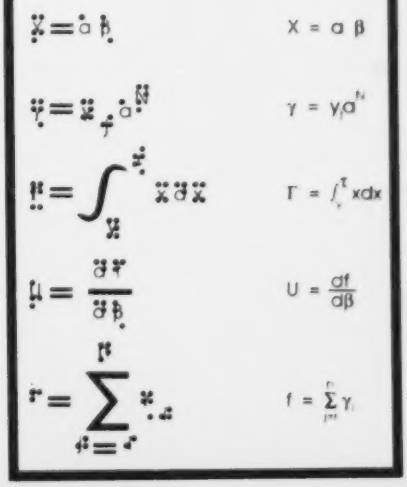
Dr. Gardner's research involves equations composed of braille numbers and letters, with tactile representations of the mathematics symbols replacing the often ambiguous braille mathematics symbols. Equations are presented in a spatial format as they are for sighted people. Fractions are printed as numerator over denominator; subscripts and superscripts are printed in their proper positions; and limits of sums and integrals are printed in their normal positions. The symbols are represented by compact tactile patterns that can be read more easily than the braille mathematics symbols. An eight-dot braille cell has been adopted by the Dots+ protocol. The enhanced cell can represent alphabetic characters, Greek, italic, bold, script, etc. Non-overprinted attributes (for example, vector signs, dots, carets, and tildes) are printed normally with some enhancement for readability.

New raised-print technology permits embossing scientific equations, figures, and diagrams. Development and testing of an equation-printing method that retains the intuitive and conceptual advantages of the standard spatial representation of mathematics equations is now under development.

In 1992, a packet of information describing Dots+ and containing tactile examples was sent by Dr. Gardner to about 50 experts in the U.S. and Europe—blind mathematicians, scientists, engineers, and educators interested in issues of accessibility of blind students to mathematics and science. The material was received enthusiastically by the reviewers. **Two texts are being tested: one for discrete element mathematics for blind undergraduates and another for introductory algebra for freshman high school students. Wide testing of the mathematics texts is planned once the materials have been revised.**

The Programs for Persons with Disabilities (PPD) within the Division for Human Resource Development is funding the Dots+ project at Oregon State University. The PPD is responsible for bringing about needed changes in academic and professional climates in science and engineering for persons with disabilities, including increasing the awareness and recognition of the capabilities of students with disabilities, promoting the accessibility and appropriateness of instructional materials and educational technologies, and increasing the availability of mentoring resources.

New Braille System Developed by John Gardner, a blind Oregon State University Professor



U.S. Senators Laud NSF Project Selected as the 1992 Anderson Gold Medalist Winner

In praise of Access 2000, the 1992 recipient of the prestigious Anderson Medal, Illinois Senators Simon and Mosely-Braun jointly wrote "Access 2000 has successfully brought together diverse stakeholders in Chicago's educational system to work cooperatively to improve the lives and learning of children in our schools." Access 2000 is a Comprehensive Regional Centers for Minorities (CRCM) project.

This CRCM project is located at Loyola University in Chicago and is one of 14 Centers across the nation. **These Centers impact nearly 30,000 pre-college students** through several activities including: curriculum reform, teacher enhancement, mentoring, advance placement classes, special field trips to research laboratories, and parent-student seminars. **This particular Center serves nearly 2,000 precollege students.** The Anderson Award has provided visibility to the educational efforts at Loyola University and has allowed the CRCM project there to leverage additional support of over $300,000 from a variety of sources. In addition, the award increases credibility of the CRCM with parents, students, and other constituencies.

The Anderson Medal, awarded annually by the American Council on Education's Business-Higher Education Forum, recognizes the most outstanding partnerships nationwide among business, higher education, and public schools. It is the first national award to honor alliances among all three sectors: business, school, and university. Members of the Forum are CEO's of major corporations and presidents of major universities, including ITT, Rockwell, TRW, and Kodak, along with Harvard, Stanford, Spelman, the University of Michigan, and the University of Chicago.

This medal is especially relevant today when the need for private sector support of and involvement in education is critical to the success of education reform efforts. The medal, given in honor of Robert Anderson, Chairman Emeritus, Rockwell International and a former Forum Chair, honors local school reform efforts at the city, county, or regional level.

1992 ANDERSON-GOLD MEDAL WINNER

EPSCoR Builds Science & Technology Competitiveness

While the core of the Experimental Program to Stimulate Competitive Research (EPSCoR) initiative is the support of research in science and technology, complementary initiatives in science and mathematics education and human resource development have enhanced the ability of EPSCoR states to field a science and engineering work force capable of competing for R&D dollars either in the academic or industrial settings. For example, the Montana EPSCoR project continues to build on a 13-year legacy of scientific and technological achievement. Perhaps the most publicized achievement results from the book and subsequent motion picture *Jurassic Park*, whose leading character was based upon John R. Horner, a Montana archeologist who received funding in the early stages of his work. Within his discipline, his work resulted in new scientific understandings. Within his state, a new museum, The Museum of the Rockies, has been built not only to conduct cutting-edge paleontology research but also to bring numerous visitors to Montana to explore the world of science. Horner and his colleagues, such as Montana State graduate student Mary Schweitzer, have charted new paths in the field of paleontology. Schweitzer's current work on the extraction of biologically active DNA from the 65-million-year-old bones of an almost perfectly preserved 45-foot Tyrannosaurs rex that was discovered five years ago in the badlands of Montana has received national attention through the recent publication of her results in the *Journal of the American Medical Association*. Research such as this has helped to rekindle the interest of another generation of school children in the pursuit of science.

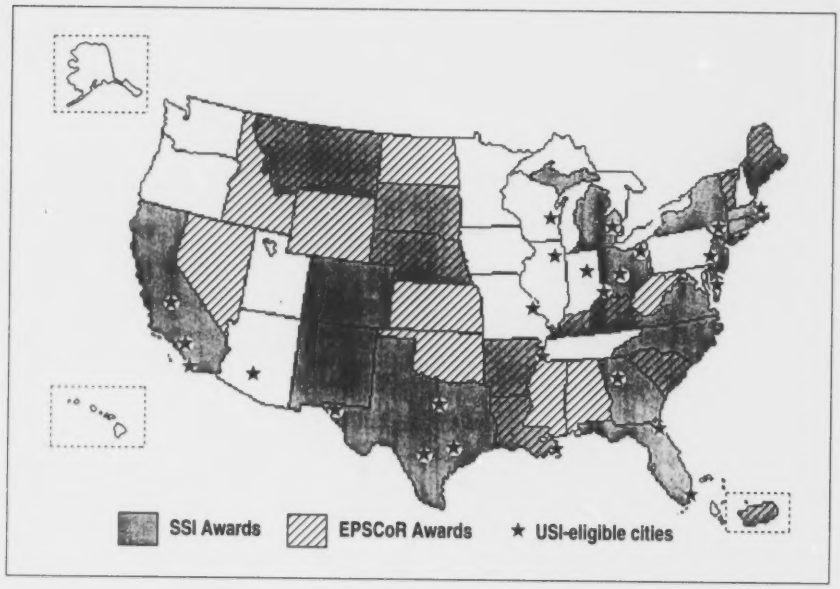
In addition to increased research competitiveness, the program has been characterized by new linkages between university researchers and state groups charged with the transfer of scientific knowledge from the work bench to the marketplace. To ensure that these initiatives have strong public support, statewide EPSCoR steering committees are articulating the role of basic research within state economic goals in science and technology to their political leadership. Academic, state government, and private sector groups have come together in many states to create policy advisory groups in support of the EPSCoR objective of increased R&D competitiveness. For example, the Kansas Science & Technology Council has been recently established, while the Kentucky Science and Technology Council, Inc. was reaffirmed to promote science and technology development within the state.

The EPSCoR leadership has played a direct role in some states in formulating science and technology policy. Members of the Mississippi Research Consortium, the governing board for the state's EPSCoR initiative, were selected to serve on the Governor's Committee on Science and Technology, and a member now chairs the Mississippi Research Authority. The Nevada Industry, Science, Engineering, and Technology Task Force has been created to develop a statewide technology-based economic development initiative. Several other EPSCoR jurisdictions have similar public/private initiatives underway that also have resulted in increased awareness of the important contributions that science and technology can make to a state's economic viability, including the Arkansas Science and Technology Authority, the Oklahoma Center for the Advancement of Science and Technology, the Maine Science and Technology Foundation, the Louisiana Education Quality Support Fund, the South Dakota Future Fund, and the Wyoming Science, Technology, and Energy Authority. These organizations grew out of EPSCoR activities and now provide substantial state financial support for S&T activities that was absent prior to the initiation of EPSCoR within the state.

Systemic change within the context of EPSCoR relates to (1) new resource flows and organizational structures; policies, programs, and practices in support of enhanced research competitiveness that extend beyond the duration of the EPSCoR awards; (2) new modes of interuniversity and university-private sector collaboration; and (3) new working relationships between and among universities, Federal agencies, state government, private sector, and other stakeholder communities within a state.

While the number of states eligible under the EPSCoR program are determined by Congress, the program continues to expand its impact in those states by holding competitions for a variety of research activities, including Experimental Systemic Initiatives and Systemic Improvement Awards. NSF's EPSCoR currently affects science and engineering faculty in 51 colleges and universities in 18 states and the Commonwealth of Puerto Rico.

USI: A Revolutionary Transaction



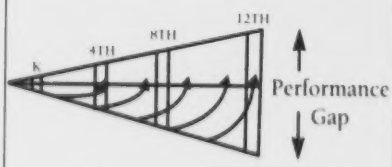
The 25 cities with the largest number of school-age children living below the poverty level are participating in an exciting new NSF program, the Urban Systemic Initiative (USI). This program has energized entire school districts and cities with its emphasis on a holistic approach to reform the entire K–12 science, mathematics, and technology (SMT) education enterprise. Its insistence on dealing with all of the multiple factors that must be brought into play produces meaningful, long-lasting improvement in student outcomes. Meeting the goals of the USI program will enable each city to prepare all of its students for meaningful participation as citizens, produce a work force for the high technology industry needed to compete in the global economy, and greatly increase the number of minorities, women, and students with disabilities in careers in science, mathematics, and technology.

The USI program is unique in several aspects. For the first time, the school districts, in partnership with NSF, are the site of the action, not players to be acted upon by outside forces. This has encouraged the USI Superintendents to develop plans to use SMT reform as the centerpiece for reform of the entire educational system. It has also allowed the districts to gather all of the key stakeholders such as city government, parent and community groups, science and mathematics professionals, university faculty, informal science education programs, and other large-scale education programs under a common plan in support of the school system. USI cities are emphasizing competition against a standard of excellence, rather than against each other. This has brought about a remarkable degree of cooperation and sharing of ideas and experience between the eligible cities. This cooperation has been fostered in meetings sponsored by NSF for the cities in the past 18 months, along with numerous visits and other communication. Through these efforts, cities have exchanged ideas on a wide variety of topics including SMT curriculum and instruction, reform of their data gathering and student assessment programs, outreach to parents, and the use of educational technology.

All of the 25 eligible cities have received USI planning grants and are engaged in a self-study to determine the current state of their SMT education program. The planning awards also support the preparation of an implementation proposal. Award of an implementation grant will allow the cities to bring about what is clearly the first ever and possibly the most meaningful improvement in SMT education in cities during the past three decades.

In FY 1994, USI plans to fund 7-8 implementation projects. The projects will target up to 500,000 students in 500 schools. USI hopes to have implementation projects in all 25 cities by FY 1998.

REDUCING THE GAP



NAEP MATHEMATICS DATA

8th graders performing at or above basic achievement level

White:	**73%**
Latino:	**37%**
African American:	**26%**

Note: Figure is not drawn to scale.

USI Chicago Planning Award: "...What Was, Will Not Be"

Since its inception a year ago, the USI planning process is already producing important changes in the school system.

The Chicago School Reform Act has mandated that each of the city's schools is governed by a Local School Council (LSC) with the authority to hire and fire principals and manage all important aspects of the school. According to a local community activist:

"The USI challenge is, in fact, the best test to date of the Chicago school reform initiative. Really, for the first time, the local school council policy-making and accountability process will be instruction-driven instead of budget-driven."

The proposed reform of the entire K–12 science, mathematics, and technology education program has forced this change in focus. The LSCs and the Chicago Central District has developed an innovative plan of Leadership Institutes involving all elements of the school community, administration, teachers, parents, and students in bringing about change. One dramatic change already decided upon is the decision to make the completion of algebra by all students by the eighth grade a goal of the system. The District is also committed to increased science and mathematics course requirements for graduation from high school.

The Office of the Mayor, in reaching out to all of the stakeholders in the community, is playing a direct role in the reform effort. As part of the proposed plan, Community Mathematics and Science Specialists, drawn from the community, will be charged with communicating the need for change in SMT education and explaining the changes to the community at large. They are the link between the school system, parents, community, and key stakeholders. In another important step, the Chicago USI (CSI plan) will incorporate the existing Comprehensive Regional Center for Minorities, Access 2000. Chicago is using computer technology through its CSI Resource Menu to link all of the city's science- and mathematics-rich resources.

The Chicago USI planning team has well stated the change that has occurred as a result of the USI challenge:

"...beyond the nuts and bolts of a competent CSI plan is an even more necessary condition—the determination to change, to be corrected, and the insistence that what was will not be."

" From parents and community activists to educators and the Superintendent and the Mayor, Chicago is ready to accelerate and transform its effort to make serious science and mathematics a natural, accessible, and normal part of every child's life."

EHR: Providing and Promoting National Leadership

In addition to its projects and initiatives, EHR supports several large-scale programs that provide national leadership in science education reform.

For example, through NSF support of the National Academy of Sciences' National Research Council, the Mathematical Sciences Education Board has developed several publications on implementing and assessing the National Council of Teachers of Mathematics (NCTM) mathematics standards. The Coordinating Council on Education (CCE) has developed science content standards, and work in science, teaching, and assessment standards is underway. The National Science Resources Center (NSRC) provides leadership training to school districts on implementing inquiry-based science education programs.

The National Science Teachers Association (NSTA) Scope, Sequence, and Coordination (SS&C) Project recommends carefully sequenced, well-coordinated instruction in all of the sciences in each year of secondary school. SS&C advocates direct, hands-on experiences and assessments that require students to demonstrate their knowledge.

The American Association for the Advancement of Science (AAAS) has created Project 2061 to promote scientific literacy in the nation's schools. Through the publication, *Science for All Americans*, Project 2061 has articulated the knowledge, skills, and attitudes students should acquire as a result of schooling. Project 2061 has also supported alternative curriculum models to guide districts and states in identifying barriers to reform and developing the proper policy blueprints.

Statewide Systemic Initiatives Program Having Major Impact on States

The activities are having a profound effect upon educational policy issues within the states, and are projected to impact up to four million students and up to 160,000 teachers within the next few years.

The Statewide Systemic Initiatives (SSI) Program is a major effort by NSF to encourage improvements in science, mathematics, and engineering education through comprehensive systemic changes in the education systems of the states. State-level initiatives are an important way to reach the more than 15,000 school districts that make up the nation's diverse school system. Systemic and lasting educational improvement in the United States depends on effective state policies, state adoption of high-quality materials and curricula, and well-prepared teachers and administrators. Strong state education programs and policies are vital links between national education goals and classroom implementation of the practices that will help us achieve these goals.

A total of 25 states and Puerto Rico received five-year awards. Examples of some SSI accomplishments follow.

Connecticut created a nonprofit organization, the Connecticut Academy of Education, to serve as a catalyst, advocate, and broker for reforms in mathematics and science education. This small and highly focused organization has been very successful in forming strong partnerships with the Connecticut State Department of Education, higher education, local school districts, science-rich institutions, parent groups, business, and the community to implement a strong science and mathematics instricutional program in Connecticut schools. In collaboration with local media and businesses, the Academy aired lively television spots, developed a science and mathematics education supplement for the Hartford Courant, and produced children's science activities printed on tray-liners for fast-food restaurants.

The Louisiana SSI provides intensive, content-rich, classroom-focused summer workshops for the state's teachers with carefully organized academic-year follow-up to implement high quality science and mathematics instruction for all students. Site coordinators with extensive classroom experience bridge the gap between university faculty and participants. The Board of Regents, the Board of Elementary and Secondary Education, the Governor, and the Legislature have given strong support to the initiative by committing $10 million in state funds to it. The initiative has an overwhelming number of teachers and schools apply to participate in these programs. In a recent hour-long statewide television call-in hosted by the Governor, the number of enthusiastic calls from parents and teachers praising the Louisiana SSI was phenomenal.

The Montana SSI redesigned high school mathematics curriculum and assessment using an approach that relates mathematics to real-life problems and to other disciplines. To the delight of teachers and students, computers and graphing calculators are critical tools of the new curriculum. In the schools where the new curriculum is piloted, results showed improved student problem-solving skills and increased interest in mathematics.

Although the SSI program is not hosting a competition presently, the existing projects continue to expand their activities in the states. The activities are having a profound effect upon educational policy issues within the states, and **are projected to impact up to four million students and up to 160,000 teachers within the next few years.**

New Rural Initiative Completes the Educational Systemic Reform Trilogy

National tests in science and mathematics achievement indicate a performance gap across ethnic groups and regions of the nation. This gap has been attributed to a number of factors, but is strongly linked with the level of economic poverty of students and the regions in which they reside. Data show that students in extreme rural or disadvantaged urban areas receive the least exposure to college-preparatory science and mathematics courses.

NSF has begun the development of the Rural Systemic Initiative (RSI), which joins two previously established educational reform programs, the Statewide Systemic Initiatives and the Urban Systemic Initiatives. RSI targets those regions of the nation that are characterized by low population density and high levels of economic poverty. RSI is unique among the trilogy of educational systemic reform efforts in that the "regions" are not defined political geographic structures, but rather are determined by a collaborative effort of partners who share a vision of educational reform in school districts that have similar backgrounds and cultures and face common educational and economic barriers. Collaborations are encouraged among school districts that are not necessarily in the same states, or among school districts which are not necessarily contiguous.

During the first year of the Initiative, NSF has actively sought input from rural educators, and from rural communities themselves. A variety of conferences and workshops that focus on rural education and infrastructure issues have informed the development of the programmatic guidelines. The Appalachian Rural Conference, held in West Virginia, addressed educational issues and gathered recommendations from participants, who included parents, teachers, school district and state educational administrators, state legislators, and business and industry representatives. The Rural West Conference in Colorado focused on educational barriers experienced by rural, poor American Indian and Latino students and enlisted the expertise of a number of professional societies involved with these students.

With the completion of the programmatic guidelines, proposals are being solicited for planning and development projects, requesting that interested individuals or groups establish regional coalitions to articulate their visions for science, mathematics, and technology education; to develop baseline analyses; and to identify a strategy for implementation of educational reform efforts. Program staff will work closely with planning and development awardees as they structure their plans and goals. This cooperation will achieve effective implementation strategies that will significantly impact the instruction provided to rural, economically disadvantaged students and will address community infrastructure issues needed to ensure that reform efforts are sustainable.

Over a five-year period, RSI plans to fund Implementation Awards in up to eight rural regions.

Are Today's Students Learning Science and Mathematics? Just Look at the Indicators

A "must have" for policymakers engaged in promoting systemic change in science and mathematics education across the nation, the Indicators of Science and Mathematics Education report differs from many other education report cards: it not only displays figures and charts but provides easy-to-read explanations of what the data mean. First in a series of reports from the Indicators Program, this report presents nearly 100 statistical indicators on the quality of the United States science and mathematics education system from kindergarten through graduate school.

The report, which is to be revised every two years, can be used by researchers; Federal, state, and local government policymakers; and school administrators in their quest to answer questions such as "Has student achievement in mathematics and science increased in the last 20 years?"

In addition to answering this and other questions about trends in student achievement in the report, the inaugural volume is exclusively devoted to indicators of K–12 math and science education, covers the science and mathematics curriculum, teachers, course persistence and career choice, and higher education. The next report will be published in 1995.

Mississippi AMP Program: Making a Revolutionary Difference

The Mississippi Alliance for Minority Participation (MAMP) project is setting new standards for achievements in the Alliances for Minority Participation (AMP) Program. From 1989 to 1991, the number of minority individuals completing Science, Engineering, and Mathematics (SEM) B.S. degrees in Mississippi declined from 268 to 202. Since the representation of minorities in SEM was already low, this disturbing trend indicated that major changes in SEM education were necessary. The Mississippi Institutions of Higher Learning (MIHL) knew it was a challenge to all public institutions in the state to develop a strategy to better address the needs of a large segment of the state's population that was being underserved. MAMP was created as a desirable strategy to unite SEM academic leaders, business leaders, and government officials. MAMP's first challenge was to identify and coordinate all targeted projects and to develop stronger lines of communication and dissemination between Mississippi educational institutions and other segments of the state. Using the MAMP strategy, a message was sent out to all students in the state indicating that the study of SEM was important and the educational institutions in Mississippi are committed to help them achieve in SEM. MAMP institutions jointly developed summer bridge programs for precollege students, group learning strategies, research opportunities for undergraduates, new ways of teaching "gateway (formerly gatekeeping) courses," and numerous other activities to ensure that SEM was inclusive instead of exclusive.

In 1992, the B.S. degree production in SEM for minority individuals in the AMP institutions increased from 202 (1991) to 245 in 1992, and in 1993 the number of B.S. degrees awarded to minority students increased to 379. Enrollment increased from 2,948 in 1991 to 3,434 in 1992; and freshmen retention rates increased from 51.6% in 1990 to 60.4% in 1991. Clearly, the MAMP strategy is working. While institutions still have much ground to cover, a comment by an NSF reviewer sums up the MAMP strategy, "The idea that Historically Black Colleges and Universities would work hand in hand with traditionally white institutions in the State of Mississippi to increase the [SEM] opportunities available for minority students in Mississippi is revolutionary." The AMP program is causing revolutionary change in all institutions that it currently funds.

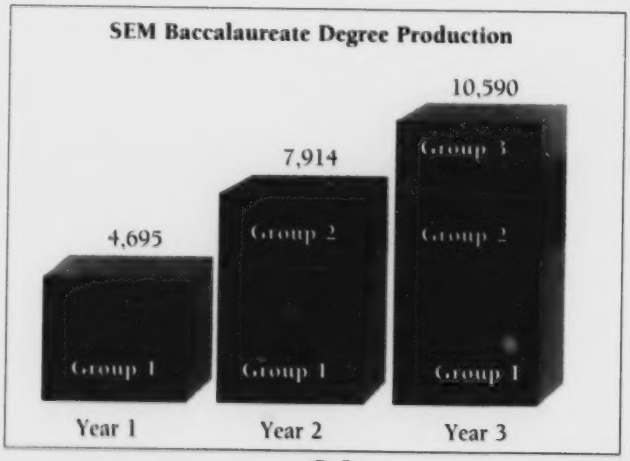
The AMP Program is a multidisciplinary and comprehensive NSF undergraduate program designed to accommodate a new paradigm for numerical goals, milestones, and measurable outcomes in a heightened accountability framework defining a new standard for the production of SEM baccalaureate degrees earned by individuals from underrepresented groups in these areas.

AMP supports alliances via cooperative agreements that contain each alliance's goal (the current number of individuals from minority groups obtaining B.S. degrees in SEM and the alliance's five-year goal) and specific work statements that describe how the alliance will achieve its goal. Each alliance agrees to participate in an annual three-phase project review process that involves a site visit, an annual report, and a reverse site visit. **The AMP Program impacts more than 75,000 undergraduate students annually.**

NSF currently supports fifteen AMP projects nationally. Six were initiated in November 1991 (Group 1—Alabama, Arizona, California, Mississippi, Texas, and Puerto Rico), five in November 1992 (Group 2—Florida, New York City, North Carolina, South Carolina, University of Texas System), and four in November 1993 (Group 3—Chicago, California State University System, Washington, DC Area, and New Mexico). **The collective goal of these alliances is to increase the annual number of baccalaureate degrees awarded from 8,563 (baseline year) to 18,011 in five years.**

The Alliances for Minority Participation Program — SEM Baccalaureate Degree Production

Degrees awarded adhere to the National Center for Education Statistics (NCES) guidelines for reporting degrees. For Year 1, the degrees awarded cover the period from July 1, 1990 to June 30, 1991; for Year 2 the period from July 1, 1991 to June 30, 1992 is covered, and for Year 3, the period from July 1, 1992 to June 30, 1993 is covered.



Inventing Systemic Evaluation: The Bottom Line of EHR Program Evaluation

To measure the impacts of NSF's systemic education initiatives, EHR is inventing "systemic evaluation." Perhaps most important is the ongoing evaluation of the Statewide Systemic Initiative (SSI) program. In collaboration with the Office of Systemic Reform, the Division of Research, Evaluation, and Dissemination (RED) is overseeing an ambitious effort to measure systemic change in the development and delivery of mathematics and science education in the 25 SSI states and the commonwealth of Puerto Rico.

Systemic evaluation is the most complex of the EHR program evaluations: six are in progress, with another six scheduled in FY 1994. As more of EHR's 33 programs are evaluated, the results will be used to shape priority setting, policy decisions, and program budgets.

EHR evaluations range from less-than-one-year efforts to multiyear examinations. "Formative" evaluations focus on program planning and implementation, while "summative" evaluations capture the lessons learned for initiating new programs and improving existing ones. In both the short run and the long, program evaluations measure return on investment. As such, they are an accountability and management tool that can discern changes in infrastructure (new partnerships, curricular approaches) as well as outcomes (student performance, teacher enhancement).

All programs are evaluated by "third party" independent contractors who are selected on a competitive basis. EHR evaluations comprise a continuum of oversight activities that include two categories in addition to full-blown evaluations:

- Impact studies are conducted by external evaluators (sometimes a Blue Ribbon Panel). These studies yield a report on processes and outcomes that is more limited in its focus, data collection, and analysis. Impact studies are usually more formative than summative.

- Program monitoring is done by program officers, with technical assistance provided by EHR/RED Evaluation staff. The purpose is two-fold: to collect data on program characteristics and events on a continuous basis and to build a culture of evaluation competence among program officers. Such assistance is intended to inform the Program Officer about the extent to which program goals and management objectives are being met. Program monitoring begins with consultation between the Evaluation staff and the cognizant Program Officer and Division Director; it leads to better programs and program management.

With the aid of EHR's "User-Friendly Handbook for Project Evaluation," NSF is training its program officers to provide technical assistance to principal investigators who seek to evaluate the outcomes of their projects. The handbook (and an accompanying video) will soon be available through workshops in the field to support education researchers and practitioners in evaluating their activities.

The "bottom line" of evaluation is learning whether EHR programs are making the kinds of differences—systemically as well as for targeted purposes—that NSF intends. If so, then the task becomes one of transferring the lessons of evaluation to new settings. Such "dissemination" expands NSF's contribution to mathematics and science teaching and learning.

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Information on the programs of the Education and Human Resources Directorate (EHR) can be obtained from any of the EHR Division Offices:

Office of Systemic Reform	703/306-1690
Division of Elementary, Secondary, and Informal Education	703/306-1620
Division of Graduate Education and Research Development	703/306-1630
Division of Human Resources Development	703/306-1640
Division of Research, Evaluation and Dissemination	703/306/1650
Divison of Undergraduate Education	703/306-1670

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The cover photo was taken at the premier of the PBS Back-to-School Special "Good Morning Ms. Toliver," an NSF funded half-hour television show produced by the Foundation for the Advancement of Science Education.

This show was named in April as a winner of the 1993 George Foster Peabody Award, the prestigious award designed to recognize distinguished achievement and meritorius public service by radio and television networks, stations, producing organizations, cable television organizations, and individuals.

It is the most competitive of the many entertainment awards.

The National Science Foundation (NSF) funds research and education in most fields of science and engineering. The awardee is wholly responsible for the conduct of such research and preparation of the results for publication. The Foundation, therefore, does not assume responsibility for such findings or their interpretation.

The Foundation welcomes proposals on behalf of all qualified scientists, engineers, and science educators, and strongly encourages women, minorities, and persons with disabilities to compete fully in any of the research and research-related programs described in this document.

Facilitation Awards for Scientists and Engineers with Disabilities provide funding for special assistance or equipment to enable persons with disabilities (investigators and other staff, including student research assistants) to work on an NSF project. See the program announcement, or contact the program coordinator in the Directorate for Education and Human Resources.

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